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ABSTRACT

This document contains an instructional unit which deals with one major topic in ecology. It focuses on the variables which affect the development of populations and determine their final size within a given period of time. The variables operating in nature which determine the development of populations are numerous, thus complicating the task of scientists who attempt to evaluate the separate influence of each variable. To help overcome some of these problems this unit attempts to study the development of animal populations using a computer simulation. This instructional method presents a relatively simple simulation of the complex realities of animal populations. The booklet was designed to guide the student through the content being addressed and introduce the student to the computer simulation. It also includes additional activities, questions, and summaries. (TW)

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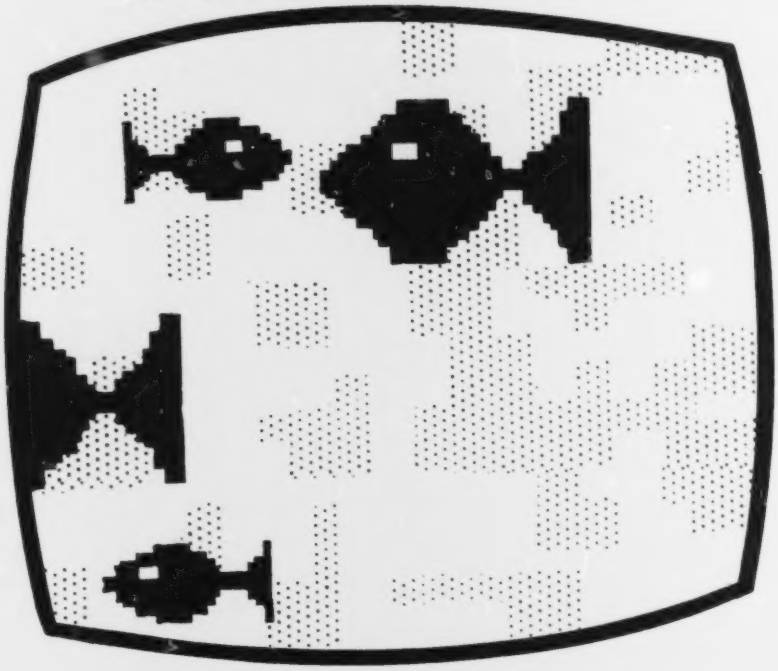
ECO LIFE

A Simulation of an Ecological System



Student Booklet

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INTRODUCTION

ECO-LIFE is an instructional unit, dealing with one topic in ecology.

Ecology is the study of plant and animal life, emphasizing the interactions between them, the way they are influenced by the environment, and how they affect it. The relationships between the number of plants in a given area, the number of plant-eating animals and the number of carnivores feeding on herbivores in the same area, is one such example.

The present unit is limited to one field of ecology - the ecology of animal populations.

What is a population ? Most animals and plants do not live in complete isolation; rather, they live in either sparse or dense groups. A number of individuals of the same species, living in the same area and multiplying within the same group, are called a population .

The present unit therefore deals with the various factors which affect the development of populations and determine their final size within a given period of time. The factors operating in nature to determine the development of populations are numerous, and this complicates the task of scientists who attempt to evaluate the separate influence of

each factor.

Another difficulty involved in studying populations in their natural environment relates to the very long time required for observing the growth and development of various populations.

To overcome these difficulties, we shall try to study the development of animal populations, using computerized simulation . This is a method which presents a relatively simple simulation of the often quite complex reality. We can study each variable related to the development of the population separately, as well as examine the interaction between a number of variables. Another advantage of the computerized simulation lies in that it enables us to speed up processes which take very long in nature, and we may observe such developments occurring on the screen within seconds.

However, the computerized simulation has some limitations as well: It is an imperfect simulation of reality, not reality itself; therefore, the results of the simulation should be examined critically.

What can you learn from ECO-LIFE?

The computerized simulation ECO-LIFE presents a simulation of a single species population, living in its habitat. In nature, there is a large number of factors influencing the development of a given population. The present simulation allows you to examine the effects of the following variables on the development of a population:

- an environmental factor: The amount of available food.
- population-related factors: The initial number of individuals in a given unit of area; the average life span in the population; the average number of offspring per individual; the age of sexual maturation; the tolerance of individuals to diet restriction and crowding.

Through examination of the relationships between these variables and the development of the population, you will become acquainted with natural processes, and you will then be able to answer questions such as "what would happen under natural conditions, if.....?"

CHAPTER A: THE CATTLE EGRETS

Any animal population living in its habitat affects its environment and is being influenced by it.

The present chapter deals with the cattle egrets population, through which we shall try to discover some natural laws which also apply to other animal populations.

Three major questions will be discussed:

A. How does the amount of available food influence the development of the population ("Habitats" activity).

B. Is there any relationship between the initial number of individuals in various habitats, and the development of the population? ("Initial number" activity).

C. How do changes in the tolerance of a given species to diet restriction (due to seasonal changes) influence the development of the population, in different habitats? ("Tolerance" activity).

ACTIVITY A: HABITATS

Today, cattle egrets may be found in many different habitats. They are seen in the fields, on sea shores, and near lakes and rivers. It is the only one of its family that can live far from water as well. Its food consists of insects, fish, amphibians, and even reptiles and rodents. The cattle egrets follow herds or single animals, and might even accompany a tractor in the fields. They are seen in large numbers near garbage dumps or public gardens in towns.

The fact that they feed on a large variety of food, enables them to survive almost everywhere; indeed, they are spread widely, almost all over the world.

Which, in your opinion, will be the major habitats of egrets?

Write down your hypothesis:.....

.....

.....

To test your hypothesis, imagine four habitats in which cattle egrets began nesting:

Habitat A: A large wood, close to the coast, to major garbage dumps and fish ponds. The cattle egrets should have no difficulties in finding food.

Habitat B: A large wood, close to large fish ponds. However, the owners of these ponds have decided to dry them up, and therefore the area of the ponds decreases each year, and cotton fields take their place.

Habitat C: A large water reservoir has been built in a semi-desert area. Trees have been planted around it; frogs, and even fish (brought by people living in the area, whose hobby is fishing) may be found in the lake.

Habitat D: A large wood in an arid zone surrounded by cultivated fields; however, there is a very limited source of food available for the cattle egrets.

Start working with the computer, and select the "Habitats" activity.

Use the simulation to examine the changes in the size of the cattle egrets population in each of the above habitats.

Run the simulation, changing the initial quantity of available food and the supplementary food quantity in habitats A to D. Note that in each habitat, the inital size

of the population is 100 cattle egrets.

Select the quantities of initial food and supplementary food in each habitat.

How will you decide on the food quantity? You may choose any number between 1 and 200 food units. Thus, 200 units should be allocated to the habitat which is rich in food, and 1 unit should be selected for a particularly poor habitat. The amount of supplementary food should be decided on a similar basis: 1-10 units is a small quantity; 50 units represent a large quantity. Remember that food units are added in each time unit. The following table will help you in deciding on food quantities.

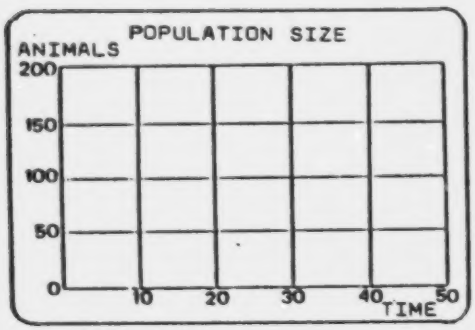
Table for characterizing habitats according to available food:

HABITAT	A	B	C	D
Initial food units	180-200	180-200	1-20	50-70
Supplementary food units	80-100	1-5	50-100	5-10

Summarize your results:

Copy from the computer the graphs describing the various habitats.

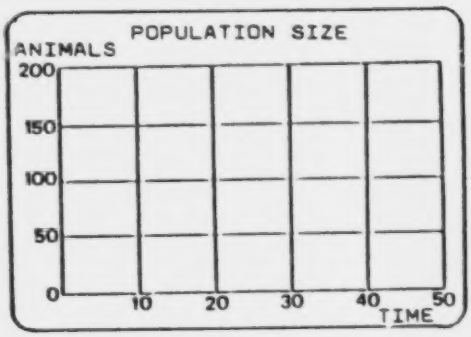
Area A



Initial food units.....

Supplementary food units....

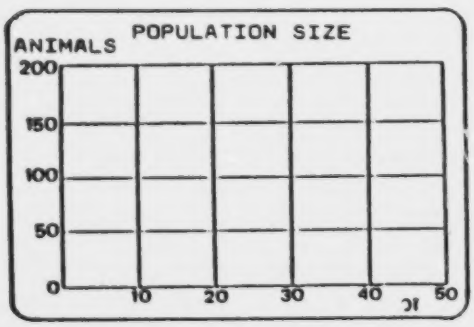
Area B



Initial food units.....

Supplementary food units....

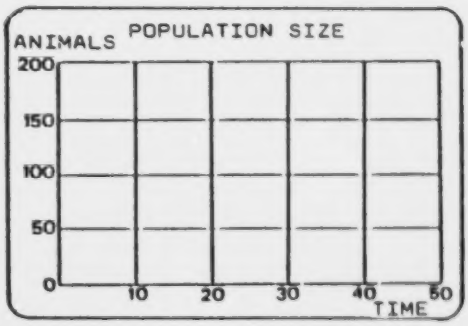
Area C



Initial food units.....

Supplementary food units....

Area D

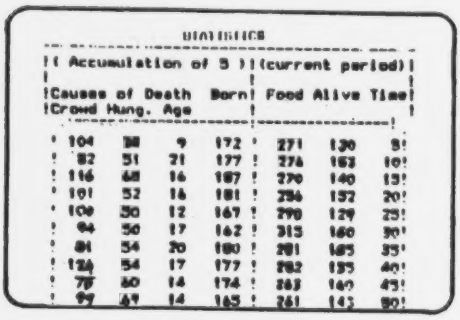


Initial food units.....

Supplementary food units....

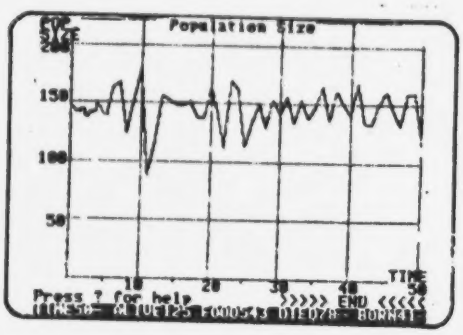
According to the results obtained from the computer, answer the following questions:

1. Habitat A is characterized by high initial quantity of food (180-200 units) as well as large quantity of supplementary food (80-100). Your results should therefore be similar to the following graph and table:



STATISTICS

(Accumulation of 5)				(current period)		
Causes of Death			Born	Food	Alive	Time
Crowd	Hung.	Age				
104	38	9	172	271	130	5
82	51	21	177	276	163	10
116	48	16	187	270	140	15
101	52	16	181	256	152	20
109	50	12	169	290	129	25
94	50	17	162	315	160	30
84	54	20	180	281	185	35
124	54	17	177	282	135	40
78	60	14	174	283	160	45
97	49	14	165	261	145	50



A..The graph reveals fluctuations of the population size, oscillating around an imaginary line which represents the average value of these fluctuations. This average line represents the size of the steady population. Thus, the change in the population size approaches zero, since the number of deaths is more or less equal to the number of births. The steady size of the population in Habitat A, as described by this graph, is approximately .....

B. Compare the changes in the population size as shown in the graph, to the changes presented by the table of data:

What is the relationship between the number of births and the number of deaths in a given period of time? Circle the correct answer: The number of births is smaller/equal/higher than the number of deaths. When the number of individuals added to the population (born or entering) are more or less equal to the number of individuals removed from it (die or exit), we have a steady (balanced) population . The state of a balanced population oscillating around a given average size (as seen in the graph), is called dynamic (changing) equilibrium .

2. Look at the graphs copied from the simulation, which describe habitats B,C and D. In which of these has the population size stabilized, and what is the size of the steady population in each habitat?

Habitat B:.....

Habitat C:.....

Habitat D:.....

3. Why, in your opinion, are there differences in the size of the steady populations living in the different habitats? In your answer, refer to the table of data, which shows the reasons for the death of individuals in the population:.....

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SUMMARY

Food and living space are important for the life of the population, and they are determined by the habitat. The capacity of an environment to support a population of living organisms is called carrying capacity of the environment. The carrying capacity of an environment for a given plant or animal may be defined as the number of individuals per area unit .

It is obvious that environments rich in food have a higher carrying capacity than environments poor in food. That is, the number of individuals per area unit in a balanced population, would be larger in a food rich environment, as compared to an environment poor with respect to food . It is possible, therefore, that in a poor environment the population will become very small, or even liable to extinction.

Go back to your hypothesis regarding the distribution of cattle egrets. Would you like to change it, or add other areas? .....

.....

ACTIVITY B: INITIAL SIZE

As you have seen in the "habitat" activity, the size of the cattle egrets' population in each habitat changed as a function of available food (available food is the food which is available for immediate consumption). The egrets' population decreased as the amount of available food decreased, and vice versa.

The initial number of egrets with which you have worked until now, was large. If the initial size of the population was very small, would it have changed the <u>steady size</u> of the population in these areas?

Write down your hypothesis:

If we begin with a small population, then .....

If we begin with a large population, then .....

Start working with the computer, and select the "initial size" activity. Here you can examine the development of the cattle egrets' populations in each habitat, while changing the initial size of egrets, from 4 and up to 200. Use the table for characterizing habitats (which appears in Activity A), to determine the amount of food in the various habitats.

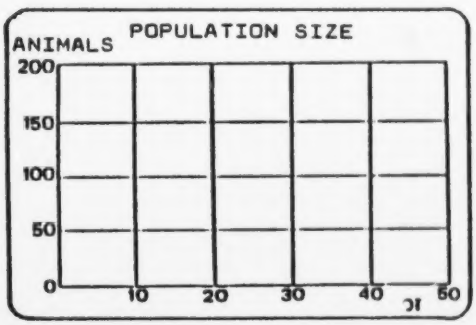
Summarize your results. Copy from the computer screen the graphs describing the populations resulting from small and large initial size in the various habitats. Compare these graphs to those obtained in the "habitats" activity.

Summarize your results:

Copy the observed graphs.

Area A

Small initial population

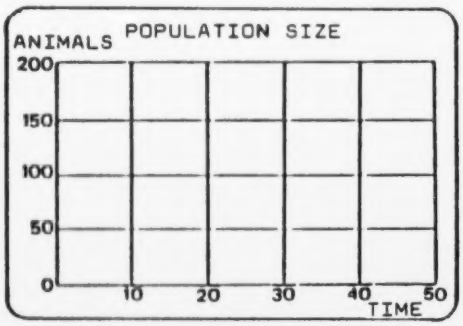


Initial size.....

Steady population size.....

Stabilyzing time.....

Large population size



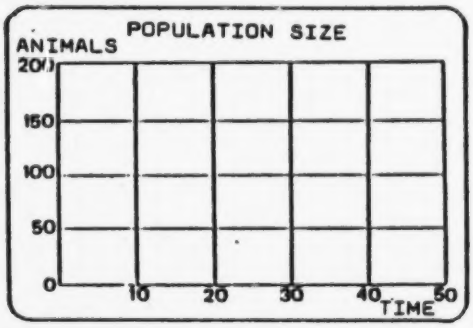
Initial size.....

Steady population size.....

Stabilyzing time.....

Area B

Small initial population

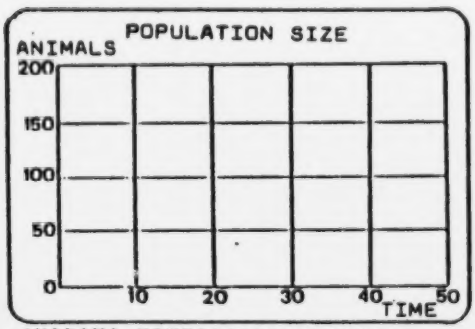


Initial size.....

Steady population size.....

Stabilyzing time.....

Large population size

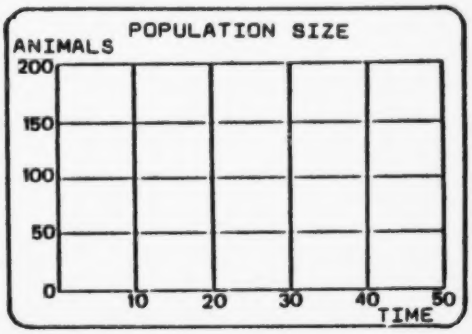


Steady population size.....

Stabilyzing time.....

Area C

Small initial population

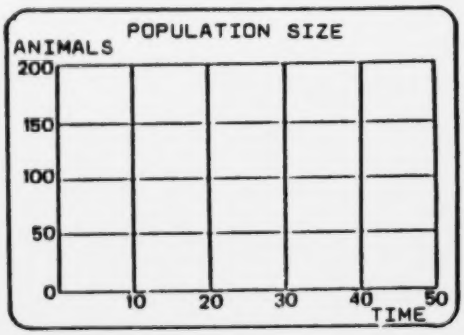


Initial size.....

Steady population size.....

Stabilyzing time.....

Large population size

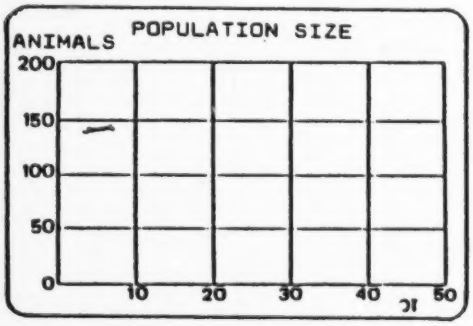


Steady population size.....

Stabilyzing time.....

Area D

Small initial population

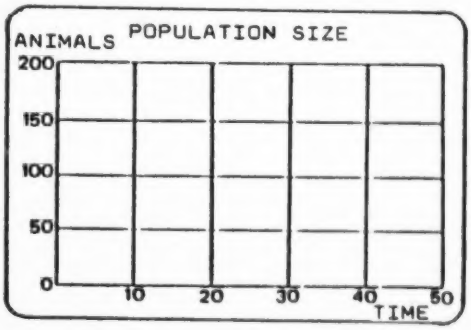


Initial size.....

Steady population size.....

Stabilyzing time.....

Large population size



Initial size.....

Steady population size.....

Stabilyzing time.....

Answer the following questions, on the basis of your results:

A. In each habitat, is the steady population size resulting from a small initial size similar to that observed when the initial size was large? Can you explain why? Use the table of data. .....

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.....

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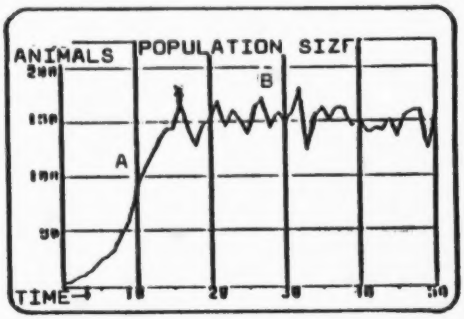
B. When you ran the simulation with a small initial size, in habitat A, your results were probably similar to the following graph and table:

STATISTICS

(Accumulation of 5)				(current period)		
Causes of Death			Born	Food	Alive	Time
Crowd	Hung.	Age				
0	0	0	21	613	25	5
1	0	4	48	600	88	10
100	0	16	174	545	146	15
162	0	22	191	505	153	20
109	1	24	190	296	138	25
179	1	21	218	255	150	30
148	5	30	198	230	165	35
173	4	25	192	244	153	40
164	5	29	179	252	134	45
139	0	12	194	243	159	50



The graph consists of two clearly defined parts, A and B. Let us try to analyze the differences in the changes of the population size, as shown in these two parts of the graph. Compare the population size, as presented in the graph, to the size expressed in the table of data. What is the relationship between the number of births and the number of deaths?

In part A of the graph, the number of births is smaller/equal/ higher than the number of the deaths.

In part B of the graph, the number of births is smaller/equal/higher than the number of the deaths.

Part A of the graph indicates a steep increase of the population size. This is called exponential increase . Exponential increase is characterized by an increasing rate of population growth, as the number of individuals increases. Thus, the number of individuals added to the population increases with each time unit.

Part B of the graph shows oscillations (increases and decreases) of the population size around an average line. In the previous activity, you have learned that this indicates that the population is at a dynamic equilibrium.

Look again at the graphs obtained from the simulation: in which habitats is there an exponential increase? State your hypothesis regarding the characteristics of the habitat, which brough about the exponential increase in each of the habitats examined. Use the Data Table.

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In which habitats did the population reach a dynamic equilibrium?

Which, in your opinion, are the characteristics of the habitat that contribut to the stabilization of the population size, in each of the habitats studied? Use the Data Table.

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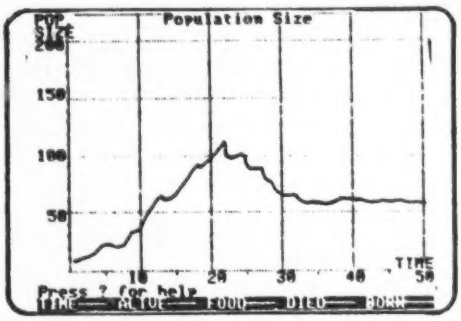
C. POPULATION A



STATISTICS

(Accumulation of 5)				(current period)			
Causes of Death			Born	Food	Alive	Time	
Crowd	Hung.	Age					
116	45	0	187	32	178	5	
10	118	17	140	7	123	10	
10	123	2	89	10	77	15	
0	70	1	64	14	62	20	
2	66	2	79	23	71	25	
0	78	1	89	17	80	30	
0	76	2	78	22	67	35	
0	68	1	62	30	62	40	
0	68	2	62	24	54	45	
0	66	1	69	23	56	50	

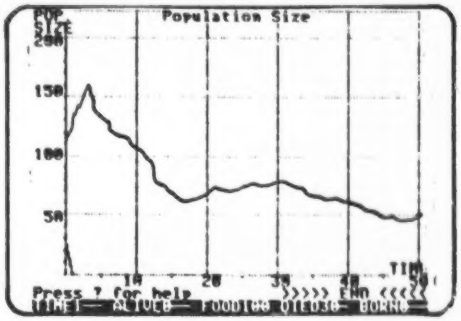
Initial size:4

Initial food:200

Supplementary food:10

Steady population size....

POPULATION B



STATISTICS

(Accumulation of 5)				(current period)			
Causes of Death			Born	Food	Alive	Time	
Crowd	Hung.	Age					
0	0	0	9	213	13	5	
0	4	3	39	167	45	10	
6	23	3	89	81	102	15	
21	78	9	114	29	106	20	
14	118	3	119	71	92	25	
3	82	3	81	16	85	30	
0	76	4	65	21	70	35	
1	74	3	79	29	71	40	
1	68	3	63	31	62	45	
0	65	3	64	37	66	50	

Initial size:100

Initial food:200

Supplementary food:10

Steady population size:....

1. Why, in your opinion, does the graph show a decrease in the size of population A?

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2. At what time unit did each of the populations stabilize? If you see any differences between the two populations, explain the reasons for these differences:

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3. Compare the ratio of births to deaths in the two populations. Fill in the following Table:

Time / No. of births	Population A: smaller/equal/higher than no. of deaths	Population B: smaller/equal/higher than no. of deaths
1-10		
10-20		
20-50		

Conclusion: Under natural conditions, the size of a steady population is determined not by the initial number of individuals, but rather by the ..... of the habitat.

Exercise for interested students:

The present activity has examined the effect of the initial number of individuals. You were asked to select the initial value from 4 and up to 200. Try a smaller number than 4 for the initial value. Run the simulation in each area with an initial value lower than 4. Describe the population observed.

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SUMMARY

Living populations do not grow indefinitely. A large number of factors limit the size of a population. Among the most important factors are:

1. Factors dependent on the population itself, such as:
   - The relationship between the number of births and deaths.
   - The number of immigrants to and from the population.
   - The tolerance of the individuals to diet restriction, crowding, etc.
2. Factors dependent on the environment, such as:
   - The quantity of available food.
   - Weather changes.
   - Predation pressures.
   - Size of the living area.

The population grows when the total number of added individuals (born and entering) is higher than the total number of subtracted individuals (dying and leaving), and vice versa.

A population is in a dynamic equilibrium when the number of added and substracted individuals oscillates around a given average.

ACTIVITY C: TOLERANCE TO DIET RESTRICTION

As you probably know, the food consumed by animals serves to build their bodies and as a source of energy for all life processes (including generating the body heat through the process of breathing). Birds (like mammals) have a steady body temperature, which they must maintain throughout the year. When the temperature of the environment decreases, the birds may suffer loss of body temperature, and freeze to death.

How, in your opinion, do birds cope with this problem?

Some birds indeed solve this problem by migrating to warmer climates. However, those birds which live all year round in the same place must increase their food gathering activity during the cold season, since food also serves as a fuel for their body temperature. Thus, the daily consumption of food of birds increases in the winter. (Food consumption = the amount of food that an animal has to eat within a given time-unit, in order to survive).

It is therefore obvious that during the warm season (summer) birds can survive under food shortage conditions better than they can during the cold season (winter). The ability to survive under conditions of food shortage (or

shortage of other needs), is called tolerance .

In the previous activities, when we examined the development of the cattle egrets population in four different habitats, we did not take the seasons, and the possible variability in the egrets' tolerance to diet restriction, into consideration. We shall now run the simulation again in the same four habitats, using the same data. This time, however, we shall change the egrets' tolerance - from high tolerance (during the summer), to medium tolerance (autumn) and low tolerance (winter).

Start working with the computer; select "Tolerance" activity.

Run the simulation, adapting the food quantities for habitats A to D (using the table for characterising the various habitats, on page **). Examine the development of the population in the different seasons:

Use the following values for tolerance:

Low tolerance (winter) - 2.

Average tolerance (autumn and spring) - 3.

High tolerance (summer) - 4.

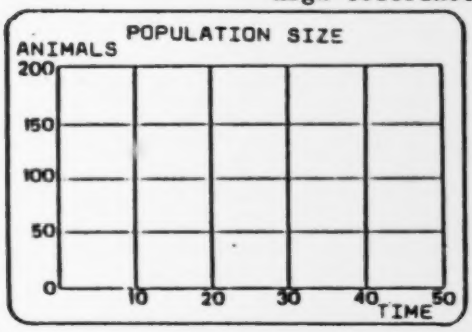
Note: The initial number of egrets is 100.

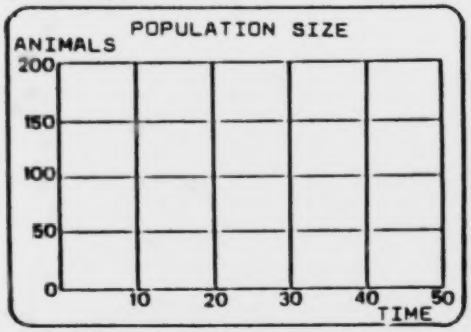
25

Summarize your results:

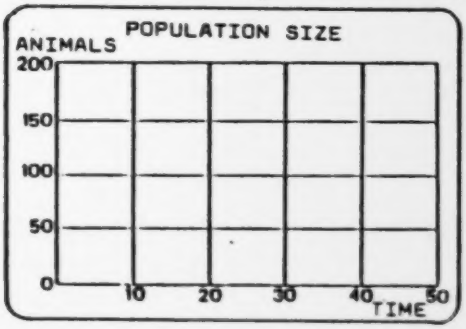
Area A	Area B
Initial food units 180-200	Initial food units 180-200
Supplementary food units 80-100	Supplementary food units 1-5

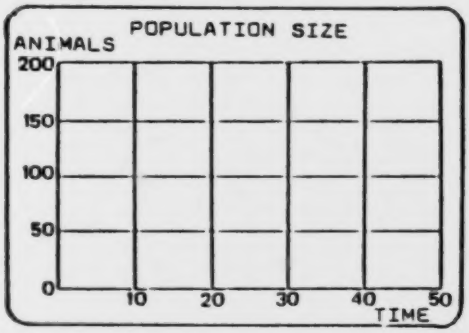
High tolerance (summer)



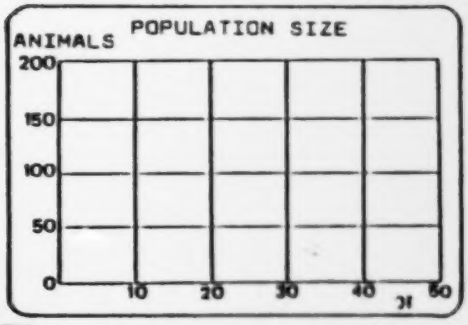


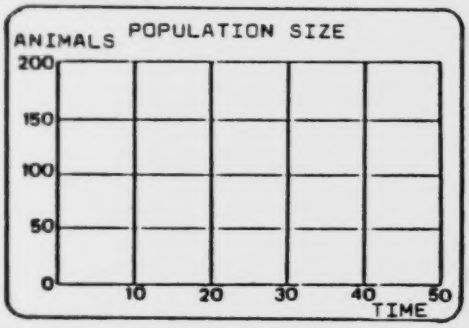
Average tolerance (autumn and spring)





Low tolerance (winter)





Area C

Initial food units 1-20

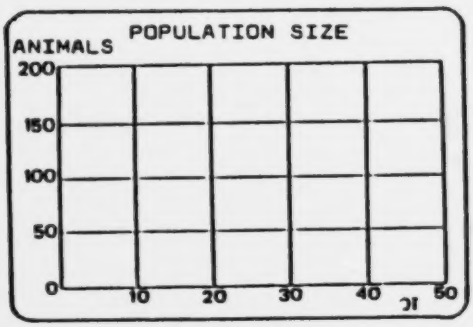
Supplementary food units 50-100

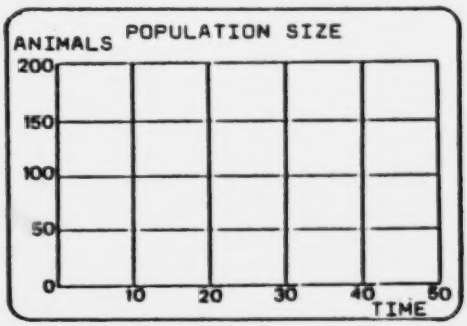
Area D

Initial food units 50-70

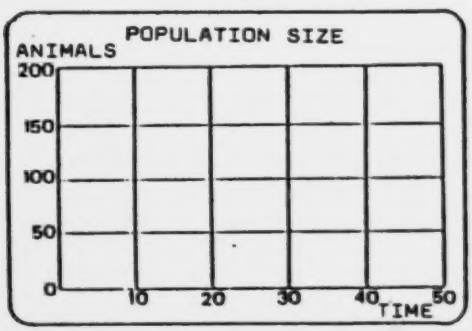
Supplementary food units 5-10

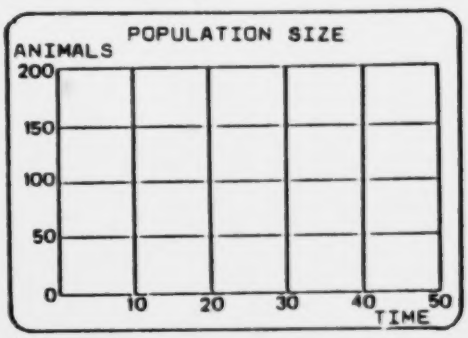
High tolerance (summer)



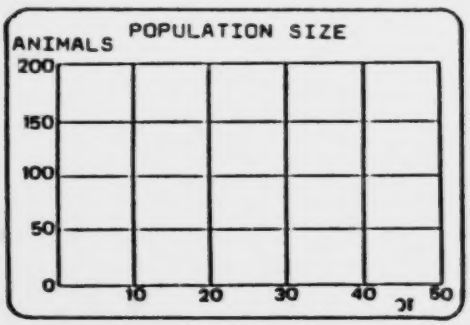


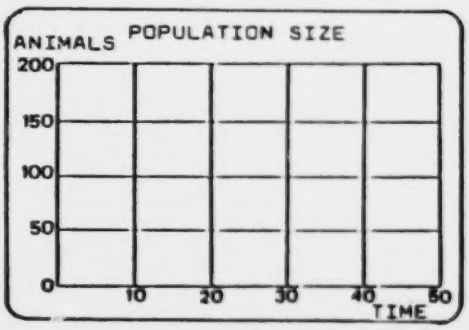
Average tolerance (autumn and spring)





Low tolerance (winter)





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Answer the following questions according to your results:

1. (A) What happened to the egrets' population in each of the four areas, when their tolerance to diet restriction decreased?

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(B) In which of the habitats did the egrets' population die out, when the tolerance level was intermediate or low?

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(C) Do you think that in nature, too, the egrets' population in areas such as C and D will always die out in the winter? If not, what, in your opinion, can happen to the egrets' population in these areas?

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2. According to your results, try to determine in which areas of the country there will be hardly any egrets during the winter. Try to reach some conclusions taking into consideration to the following point: The relationship between the level of tolerance of animals to diet restriction and their distribution in various parts of the world.

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SUMMARY

The development of an animal population in its natural environment is conditioned to many variables : Some of these variables are related to the various plants and animals which also inhabit the same area (biotic factors). The others include the temperature of the environment, the quantity of precipitation, the salinity of the earth and the water, the intensity of the radiation, the winds, etc. The latter are factors not related to flora and fauna (Abiotic factors).

The complex of all the above factors comprising a given environment is called Biotop . The factors influencing the living creatures in different biotops, may vary. Not all living creatures can adapt to such variations, and some die out, or migrate to other areas. Let us consider, for example, temperature changes: Each species has a range of temperatures through which it may survive; this range is called the Ecological Range of Tolerance. The ecological range of tolerance for temperature, or other factors, varies among different species. It may also vary from season to season, or from one member of the species to another member of the same species.

For example: When there is plenty of food , water and trees, cattle egrets may tolerate a wide range of temperature changes (a heat or a cold wave). Under shortage conditions, however, their range of tolerance will decrease, and the population of egrets will become smaller.

In the simulation excercise which you have just carried out this subject was called tolerance to diet restriction. This tolerance was high during the summer, and low during the winter. Your tolerance, too, changes with the change of seasons.

For example:

Your tolerance to water shortage is low/high in the summer;

Your tolerance to water shortage is low/high in the winter.

SUBJECT B: THE FISH POND

Fish are an important component of the diet of man, as well as that of the world's living population in general. Fish may be found not only in the oceans, which cover about two thirds of the earth's surface, but also in the lakes, rivers, streams and swamps (which also cover a considerable part of the earth surface). Nevertheless, in most developed countries, the fisheries - growing fish in artificial ponds - is a growing enterprise.

Growing fish in ponds is an expensive enterprise, requiring great investments and a lot of work throughout the year. Naturally, the goal is to reduce the expenses to the minimum, and increase the fish produce as much as possible. To achieve this, the fishermen must know how various populations of fish develop, which kinds of fish are most suitable for growing in ponds, and how to prevent the dangers awaiting the fish in the ponds. In their efforts to achieve this goal, fishermen rely on studies which follow, in a controlled manner, the development of populations of various fishes, and advise the fishermen on the best strategies. The following simulation will enable you to study this problem, and find answers which will improve your understanding of the nature of the growth of animal populations in general, and fish in ponds, in particular.

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I. THE SUITABLE FISH

Every year, as the holidays season approaches, fishermen have to work extremely hard to supply all the market's demands for fish and fish products. They are therefore very interested in finding out which is the most suitable fish for growing in ponds, ensuring the largest yield within the shortest possible time.

The number of individuals in a fish population, as in populations in general, is largely determined by the number of offspring that each female has throughout the fertile period of her life. It is clear, then, that the age of sexual maturation is of major importance.

The present chapter will deal with three major questions:

1. How does the average number of offspring per female fish, within one season, affect the development of the fish population? ("Offspring" activity)

2. How does the age of sexual maturation of the female fish affect the development of the fish population? ("Sexual maturation" activity)

3. How does the interaction of these two variables (age of sexual maturation, and average number of offspring) affect the development of the population? ("The suitable fish" activity).

ACTIVITY A: OFFSPRING

Here you will examine the relationship between the number of offspring of the female fish, and the development of the fish population. Obviously, if each female fish has a large number of offspring, the fish population will grow rapidly. But what, do you think, will happen if for some reason each female has only a small number of offspring? What, in your opinion, is the smallest number of offspring with which there will be any development of the fish population?

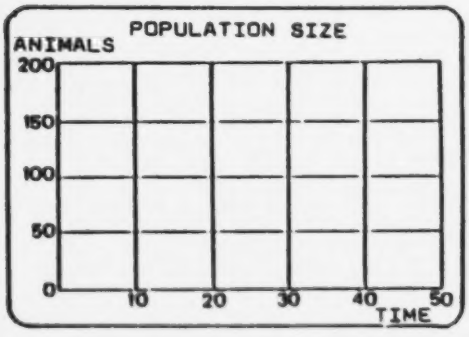
Remember: In the present simulation, only an encounter between two mature individuals will result in the appearance of offspring.

Start working with the simulation; select the "Offspring" activity.

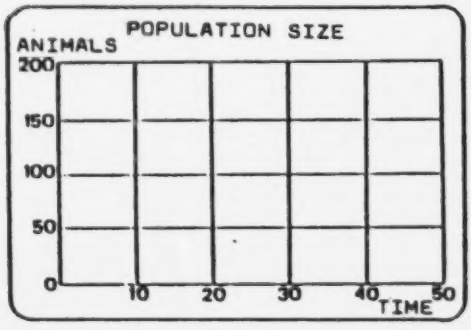
Run the simulation, changing the number of offspring from 1 to 9.

Remember: In nature, the number of offspring of different fishes may be anything from tens to thousands of fish. Due to the limitations of the simulation, however, we deal here with a small number of offspring.

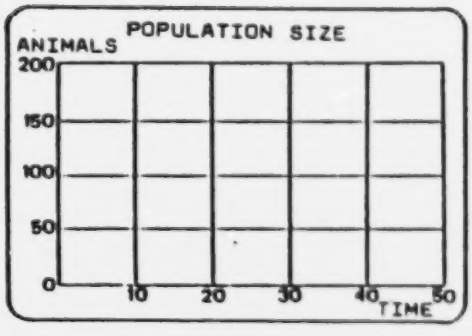
Summarize your results: Copy the graphs from the computer screen.



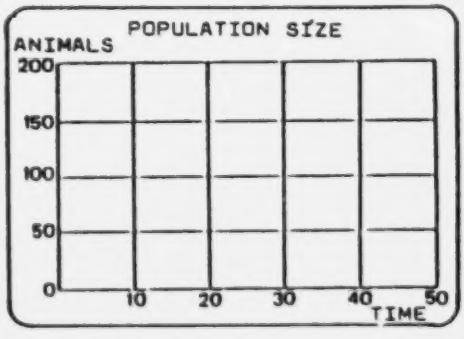
Average no. of offspring.....



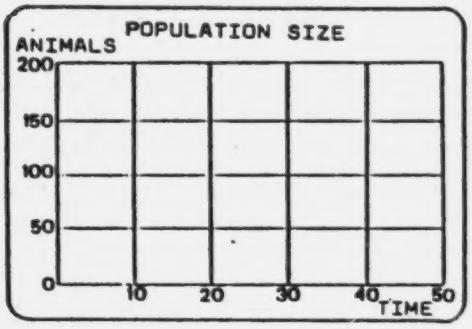
Average no. of offspring.....

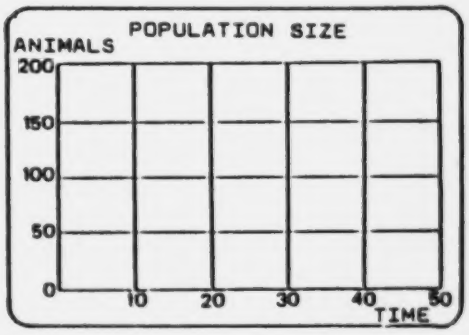


Average no. of offspring.....



Average no. of offspring.....





Average no. of offspring..... Average no. of offspring.....

Answer the following questions on the basis of your results:

1. What was the smallest number of offspring that enabled the development of a fish population? Does this result agree with your hypothesis? .....

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2. What were the major reasons for fish death, when the average number of offspring was 1? 3? 9? .....

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3. Are there differences in the size of the stable population, and in the time required to reach this steady state, between

populations whose average number of offspring is 7, 8 and 9?

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4. If you were in charge of the fisheries, which type of fish would you have chosen: A fish whose average number of offspring is 7, or 9? .....

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5. Write down your conclusions, referring to the following:

a. The relationship between the number of offspring and the form of development of the population.

b. The size of each population, and the time required for it to stabilize.

c. The major reasons for the death of fish .....

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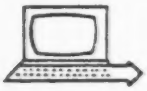
ACTIVITY B: SEXUAL MATURATION

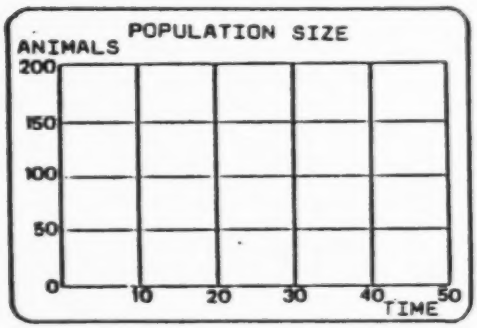
The age of sexual maturation of the female determines, to a great extent, the number of times, within her life time, the female may spawn. Earlier maturation ensures the development of the population, especially in species whose life span is short. This factor gains even greater importance in view of the numerous threats to their lives, that some animals encounter in their natural habitat.

What, do you think, may happen to a given population of animals if, for one reason or another, they reach sexual maturation at a relatively old age?



Run the simulation, changing the age of sexual maturation from 4 to 9. (The average number of offspring in this activity is 4, and the duration of life is 10).

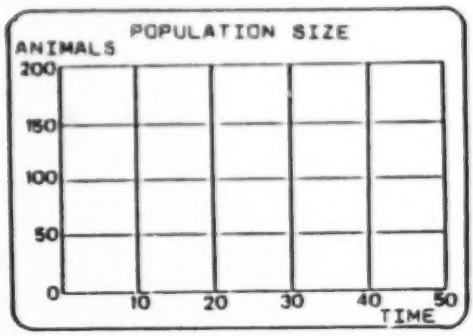
Summarize your results: Copy the graphs from the computer's screen.



Life duration: 10

Average no. of offspring: 4

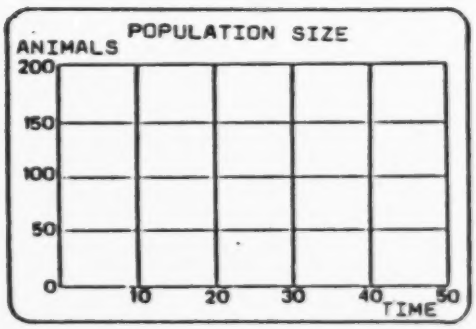
Age of sexual maturation:.....



Life duration: 10

Average no. of offspring: 4

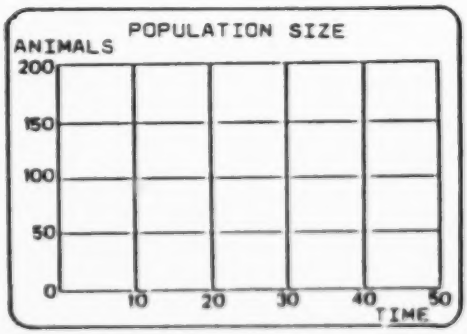
Age of sexual maturation:.....



Life duration: 10

Average no. of offspring: 4

Age of sexual maturation:.....



Life duration: 10

Average no. of offspring: 4

Age of sexual maturation:.....

Answer the following questions on the basis of your results (explain your answers):

1. Which was the oldest age of sexual maturation, at which the population could still grow? Did it agree with your hypothesis?

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2. What were the major reasons for the death of fish each time?

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3. Write down your conclusions, based on the simulation, referring to the following:

a. The size of each population, and the time required for it to stabilize.

b. The major reasons for the death of fish.

c. The realtionship between the age of sexual maturation and the development of the population.

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ACTIVITY C: POPULATION GROWTH

The previous two activities examined, separately, the effects of each of two variables which may influence the development of the population;

1. The average number of offspring.

2. The age of sexual maturation.

However, in order to find out the characteristics of the fish which best suits the fishermen, you should examine the combined effect of these two factors on the population growth. Clearly, when the number of offspring is high and sexual maturation occurs at an early age, the population will quickly reach its maximal size. It is just as obvious that with very small number of offspring and late sexual maturation, there are slim chances for fast development of the population.

The problem with which the fishermen are faced, however, is the following:

How will the fish populations develop in two ponds, in which:

a) There are fish whose average number of offspring is small (1-3), and sexual maturation is reached early (1-3)?

b) There are fish whose average number of offspring is large (7-9), and sexual maturation is late (5-9)?

Which of the two types, (a) or (b), would you recommend to the fishermen? .....

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Which options will you check through the simulation? Which values will you select? (Look at the previous activities)

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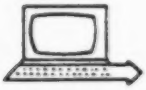


Start working with the computer (Activity C1).

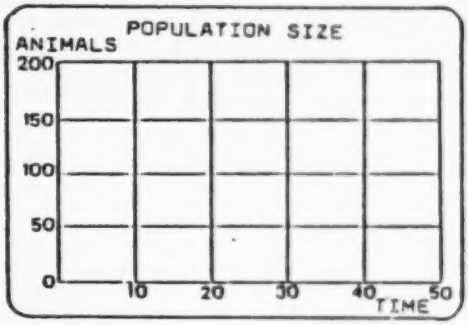
Run the simulation, changing the average number of offspring and age of sexual maturation, as you wish. (The duration of life in this activity is fixed at 10).

Summarize your results:

Copy the graphs from the computer's screen.

Examine the results; What are your conclusions? What are the differences between Pond A and Pond B?

POND A

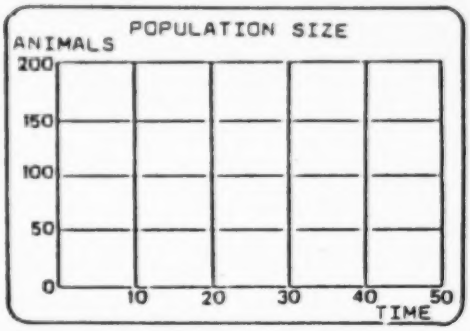


Life duration: 4

Average no. of offspring:.....

Age of sexual maturation:.....

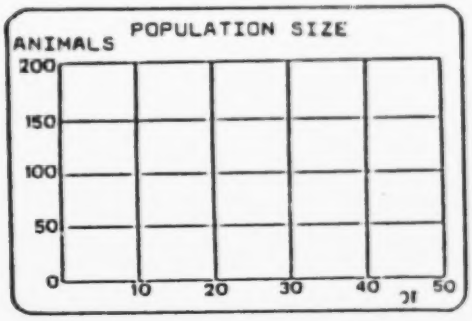
POND B



Life duration: 4

Average no. of offspring:.....

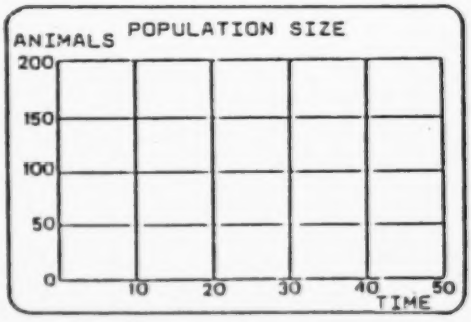
Age of sexual maturation:.....



Life duration: 4

Average no. of offspring:.....

Age of sexual maturation:.....



Life duration: 4

Average no. of offspring:.....

Age of sexual maturation:.....

Answer the following questions, on the basis of your results (explain your answers):

1. Can an early age of sexual maturation compensate for a very small number of offspring, thus enabling the development of a population? .....

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2. Can a large number of offspring compensate for a late sexual maturation, and thus enable the development of a population?

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3. Which type of fish, (a) or (b), will yield the highest number of fish whithin the shortest time interval? What, then, will you recommend the fishermen? .....

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SUMMARY

Through the co-evolution of plants and animals on earth, some balance between the various processes determining the size of each population, emerged. Factors limiting the reproduction capacity of a given species, are balanced by factors improving its reproduction capacity. For example: plants or animals which serve as food or are preyed upon to great extent or have a very short life span (such as herbs, some insects, mice, etc.) start multiplying at a very early age, and have a large number of offspring each season. On the other hand, plants and animals that live for a long time and have only few natural enemies (such as large trees, eagles, lions, elephants or even man) invest more in the individual, and their age of sexual maturation is relatively late. The average number of offspring of such species is also smaller. These examples reveal a compensatory process which has developed in nature: Processes limiting the survival chances of living populations, are balanced by processes which increase these chances. However, the variablity in nature is such that one may find populations whose number of offspring is small and sexual maturation is reached at an early age, and vice versa.